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Engine Exhaust Fumes in Fire Stations: Health Effects and General Recommendations

It is the responsibility of the Occupational Hygiene Program to investigate workplace conditions with respect to health hazards, to determine the severity of such hazards, and to recommend controls when necessary. In the late 1980s, this agency conducted a series of indoor air surveys at numerous fire stations in response to concerns expressed by fire fighters. The following discussion and recommendations were a result of those surveys. Because of the high-risk fire fighters face on the job, exposures at the stations themselves should be carefully controlled and kept to the lowest possible level.

Fire departments are encouraged to self-evaluate each station. Factors to be considered in the evaluations include building design and construction, engine types, routes of air movement between apparatus floor and crew quarters, ventilation, and actual levels of air contaminants.

Health Effects

Gasoline and diesel exhaust and their combustion products contain carbon monoxide, oxides of nitrogen and sulfur, hydrocarbons and solid particles of respirable (breathable) size. Among the hydrocarbons are formaldehyde, methane, benzene, phenol, 1-3-butadiene, acrolein and a group of compounds known as polyaromatic hydrocarbons (PAHs), several of these hydrocarbons can cause cancer. The chemical compounds can also attach to the solid particles and be carried into the lungs. Fire fighters are often exposed to cancer causing chemicals while fighting fires. The presence of diesel and gasoline fumes in the fire station extends the time, variety and dose of materials to which employees may be exposed**.** This increases the risk of cancer.

A Canadian study [Scandinavian Journal of Work and Environmental Health 14 (1988) pp. 79-90] showed that increased gasoline exhaust exposure increased the risk of developing squamous cell lung cancer. Diesel exhaust contains 30-100 times more particles than gasoline exhaust. This may increase the quantity of organic compounds brought into the lungs. This, in turn, increases the risk of cancer. As a result of this and other experimental evidence, the National Institute for Occupational Safety and Health (NIOSH) released a bulletin in August 1988 stating that diesel exhaust should be considered a potential occupational carcinogen (cancer causing agent). Since there is no known "safe" (risk-free) level of exposure to carcinogens, exposure to diesel and gasoline exhaust in fire stations should be reduced to the lowest possible level.

In addition to the long-term effects described above, combustion products may also produce acute or short-term health effects. These include irritation of the eyes and respiratory tract. The carbon monoxide in combustion gases presents a serious hazard; it can cause headache, confusion, weakness and nausea as it reduces the ability of the blood to supply oxygen to the body. At very high concentrations it can lead to loss of consciousness, coma and death. The nitrogen and sulfur oxides irritate the lungs, and may reduce the body's ability to defend itself against infectious agents and other chemicals. These effects may contribute to the combustion products' ability to cause cancer.

General Recommendations

The impact of engine exhaust emissions in fire stations on firefighters' health depends upon the intensity and duration of carbon monoxide, nitrogen dioxide and diesel exhaust exposure. The intensity and duration of exposures will vary with the number of runs, types of engines, weather conditions, ventilation, and other factors.

There are several types of actions that can be taken to reduce engine exhaust exposures in fire stations. There are measures that reduce emissions at their source (i.e. engine maintenance and local exhaust capture), prevent significant build-up of exhaust emissions (general exhaust ventilation and minimal idling times), and hinder the migration of emissions into crew quarters (door and fire pole seals).

1. Engines should be properly maintained and tuned. Exhaust and emissions control systems should be properly operating. Engines that have particularly high particulate and gas emissions, despite tune-ups, should be removed from service until repaired and used only as a last resort. If such engines must be kept in service, they should be stationed where their emissions are best controlled. The best control is local exhaust ventilation capture of emissions (See recommendation 5).

2. Regular shift run-ups of engines are not advised unless the vehicles are removed from the station. Engines should idle as short a time as possible inside the fire station, never more than one minute. If brake pressure cannot be built up in less than a minute, auxiliary airline compressors should be used.

3. The positioning of vehicles can be important. Vehicle exhaust pipes should not be allowed to blow directly against doorways or up stairways to other areas. If alternate positioning of vehicles will not improve the situation, the vehicle exhaust pipe should be redirected.

4. Other equipment with internal combustion engines should be tested outside, not inside the building.

5. Ensure adequate ventilation of the apparatus area throughout the year to prevent the build-up of exhaust gases and fumes in any part of the fire station. Flexible hoses attached to the vehicles' exhaust pipes and venting directly to the outside are the most effective methods of removing exhaust and minimizing accumulation in the fire station. Professionals are needed to oversee the design and installation of mechanical exhaust systems in order to ensure their appropriateness and effectiveness.

   In a small station with one or two vehicles and a low number of runs, and with crew quarters well sealed off from exhaust emissions, emissions may be adequately minimized by opening bay doors immediately when vehicles are started and keeping them open long enough to clear the apparatus floor of exhaust. This will not be very effective if there is poor or no cross-ventilation, weather conditions are inappropriate, or if there are staffing and security limits.

In stations with a high number of daily runs, that have poor natural ventilation, and/or have vehicles that can't be tuned adequately, a local or general exhaust ventilation system should be used. A local exhaust ventilation system uses a hose attachment to capture engine fumes at the tailpipe and exhaust the fumes directly outside. These systems have several advantages over general exhaust ventilation including that only low levels of emissions escape into room air and that less tempered air is exhausted from the space. The disadvantages for fire station purposes include maintenance, the fact that engine fumes on vehicle return would not be captured, the need to place the hose on the exhaust pipe and potential problems with system layout and installation. There are commercially available local exhaust ventilation systems that attempt to minimize these problems.

A less effective alternative is general ventilation, usually in the form of wall or window fans. These are easy to install and relatively inexpensive. For the highest effectiveness, they must be positioned close to the vehicles' tailpipes. The farther away the fans are located from the tailpipes, the more the contaminated air is likely to migrate into other areas. Because air travels the path of least resistance, there should be no openings to areas outside the apparatus floor between fan and tailpipe. In general, there should be no permanent openings at all**,** other than exhaust fans on the apparatus floors. These problems can be partially overcome by designing a partially ducted general exhaust ventilation system with large exhaust vents located where engine exhaust normally initially accumulates. Air volumes needed are generally smaller than with wall exhaust fans and fume capture is more effective. However, system layout and installation can be difficult.

In general exhaust ventilation, a two speed or variable speed fan can save on heat in the winter. A lower speed should be sufficient in preventing engine emissions from migrating into crew quarters, when used with doors and windows shut, The high speed should ensure a rapid clearing of apparatus room air. An effective system should provide a room air change every ten minutes**.** A makeup air heating unit may be needed to maintain reasonable temperatures in the wintertime.

When makeup air enters the apparatus room, as part of exhaust ventilation**,** it should be controlled and directed to enhance the clearing of engine emissions from the room air. Examples of accomplishing this might be the slight opening of a bay door opposite the fan or the automatic opening of a louvered vent in a bay door. Another example is a makeup air ventilation system with supply vents positioned to flush the apparatus floor.

Vehicle maintenance that requires engines to run inside a building must be done with adequate ventilation. Local exhaust ventilation is recommended. A flexible exhaust hose with one end attached to the exhaust pipe and the other outside the building can be effective, but, the hose must not be not too long or damaged, and the end around the exhaust pipe must fit snugly.

6. Any exhaust system installed needs to be used and maintained properly and effectively. Station personnel should be familiar with the system and how it is to be used. A general exhaust system should run long enough after vehicles leave or return to clear the air in the apparatus area. As conditions vary from station to station, system running time should be determined locally.

7. Some stations have automatic controls that turn on exhaust ventilation. They may be activated by bay door openings, by exhaust sensors, or by other means. A timer turns off the ventilation after a period of time thought sufficient to clear the air. Where such controls also control bay door operation, fail-safe mechanisms are needed to prevent accidents caused by moving bay doors.

8. Isolation is one method of controlling migration of exhaust fumes. There is a tendency for air (and engine exhaust fumes) to move between the apparatus floor and adjacent offices and crew quarters through openings of any size as a result of temperature differences, air pressure differences (because of outside winds) and human traffic between areas. Isolation measures, in effect, seal off the apparatus room from other areas. A potential problem is the trapping of fumes in the apparatus room. The significance of this depends upon the volume of the apparatus area, the rate and duration of engine emissions, the amount of time firefighters have to spend in the area, and the effectiveness of any mechanical or natural ventilation.

   a) Keep all doors leading to the apparatus floor closed when not in use. Install self-closing mechanisms on these doors. Weather-strip these doors to ensure good seals.

   b) Fire poles need self-closing lids or doors with weather-stripping that minimizes gaps. Permanently seal off those no longer in use.

   c) Install a self-closing door and its supporting walls at either the top or bottom of open stairwells connecting with the apparatus floor.

   d) Inspect seals and self-closing mechanisms for damage or wear every year and repair when necessary.

   e) Seal or weather-strip all openings between the apparatus floor and occupied areas. These openings include, but are not limited to, hose towers, pipe runs, pole holes, windows and doors.

9. Efforts to seal off occupied areas from the apparatus floor can result in inadequate ventilation in some areas. Watch rooms commonly have this problem. If additional access to natural ventilation does not ensure good ventilation, positive pressure mechanical ventilation should be provided.

10. Besides exhaust ventilation and isolation, filtering mechanisms on vehicles and in apparatus rooms are additional ways of reducing engine emissions. Vehicle engine exhaust filtering and capturing devices can effectively minimize the release of particulate into stations. However, depending on the type, they may not prevent engine gases such as carbon monoxide and nitrogen oxides from being emitted. Improper use and maintenance can lead to engine problems. Vehicles not equipped with the devices would still be a potential engine exhaust source.

    Re-circulating overhead air filtration units can save on heating costs. Properly positioned, they can do an effective job of removing airborne particulate. Special filters can remove some air borne combustion gases. Knowing when filters are no longer effective, and properly replacing them can be a problem.

11. Ensure that the annual Right to Know training required in Massachusetts includes the potential hazards of engine exhaust fumes within fire stations and other enclosed spaces.